

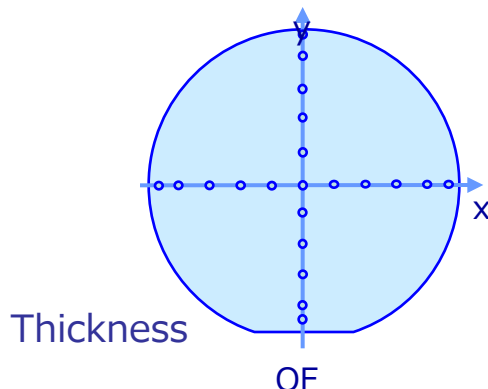
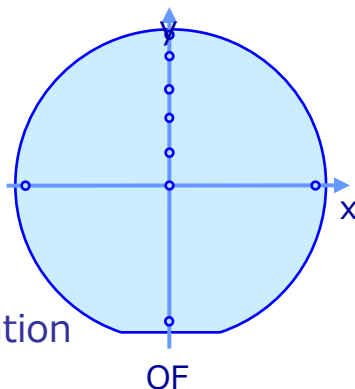


4" SiC epitaxial wafer specification for power device application

Items	HGE		Typical number	Standard	Typical number
	LB model				
Diameter	4"(100mm)	4"(100mm)	-	4"(100mm)	-
Poly-type	4H	4H	-	4H	-
Surface	(0001)Si-face	(0001)Si-face	-	(0001)Si-face	-
Off-orientation	4deg-off	4deg-off	-	4deg-off	-
Conductivity	n-type	n-type	-	n-type	-
Dopant	Nitrogen	Nitrogen	-	Nitrogen	-
Carrier Concentration	3E14-2E18/cm ³	3E14-2E18/cm ³	-	3E15-2E18/cm ³	-
-All Meas, points	±12%	±12%	±6%	±15%	±7%
Thickness	≤150mm	≤150mm	-	≤30mm	-
-All Meas, points	±8%	±8%	±3%	±10%	±4%
SD	≤0.5/cm ² (THK≤30um)	≤0.5/cm ² (THK≤30um)	-	≤1.0/cm ² (THK≤15um)	-
PDD	≤1.2/cm ² (THK≤30um)	≤1.2/cm ² (THK≤30um)	-	≤5.0/cm ² (THK≤15um)	-
DD	≤2.5/cm ² (THK≤30um)	≤2.5/cm ² (THK≤30um)	-	≤8.0/cm ² (THK≤15um)	-
BPD	≤0.2	-	0.1/cm ²	-	-

Notes

- 1) Other dimensional specifications are similar to definition in SEMI M12.
- 2) Measurement points for Carrier concentration (one direction + most OD) and Thickness
 - 4" 10mm pitch + Edge (EE = 4mm) All measurement points





4" SiC epitaxial wafer specification for power device application

[Surface Morphology]

Items	Limit	Typical Value
Roughness (Image analysis)	$\leq 2.0\text{nm (Rq)}$	0.4nm
Scratches (Image analysis)	< 1x wafer diameter	(0mm)

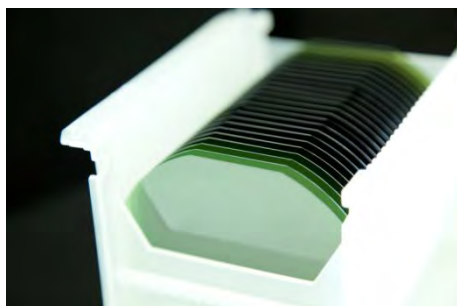
Items	Definition
PDD, DD	Detected and classified by SICA with automatic defect classifying system.
Roughness (Image analysis)	Evaluated by SICA with differential interference optical system, effective for the detection of step bunching.
Scratches (Image analysis)	Cumulative length of all scratches on the surface.

Notes:

- 1) Defect limit apply to entire surface except for edge exclusion area.
- Edge exclusion = 3mm for 4" ,6" (2mm for 3")

Options:

- 1) C-surf epi is available.
- 2) Other off orientations are available on request for provided substrates by customer.
- 3) Re-polish on backside after epitaxial growth is available on request.



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Power Semiconductor Project

Business unit center

SHOWA DENKO K.K.



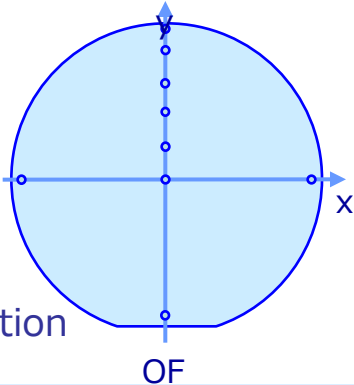
6" SiC epitaxial wafer specification
for power device application

Items	HGE		Typical number	Standard	Typical number
	LB model				
Diameter	6"(150mm)	6"(150mm)	-	6"(150mm)	-
Poly-type	4H	4H	-	4H	-
Surface	(0001)Si-face	(0001)Si-face	-	(0001)Si-face	-
Off-orientation	4deg-off	4deg-off	-	4deg-off	-
Conductivity	n-type	n-type	-	n-type	-
Dopant	Nitrogen	Nitrogen	-	Nitrogen	-
Carrier Concentration	3E14-2E18/cm3	3E14-2E18/cm3	-	3E15-2E18/cm3	-
-All Meas, points	±15%	±15%	±10%	±25%	±15%
Thickness	≤150mm	≤150mm	-	≤30mm	-
-All Meas, points	±10%	±10%	±5%	±15%	±6%
SD	≤0.5/cm ² (THK≤30um)	≤0.5/cm ² (THK≤30um)	-	≤1.0/cm ² (THK≤30um)	-
PDD	≤1.2/cm ² (THK≤30um)	≤1.2/cm ² (THK≤30um)	-	≤5.0/cm ² (THK≤30um)	-
DD	≤2.5/cm ² (THK≤30um)	≤2.5/cm ² (THK≤30um)	-	≤8.0/cm ² (THK≤30um)	-
BPD	≤0.2	-	0.1/cm ²	-	-

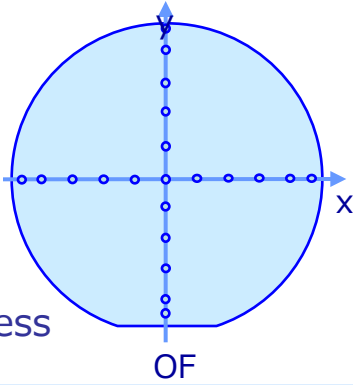
Notes

- 1) Other dimensional specifications are similar to definition in SEMI M12.
- 2) Measurement points for Carrier concentration (one direction + most OD) and Thickness

- 6" 15mm pitch + Edge (EE = 4mm) All measurement points



Carrier Concentration



Thickness



6" SiC epitaxial wafer specification for power device application

[Surface Morphology]

Items	Limit	Typical Value
Roughness (Image analysis)	$\leq 2.0\text{nm (Rq)}$	0.4nm
Scratches (Image analysis)	< 1x wafer diameter	(0mm)

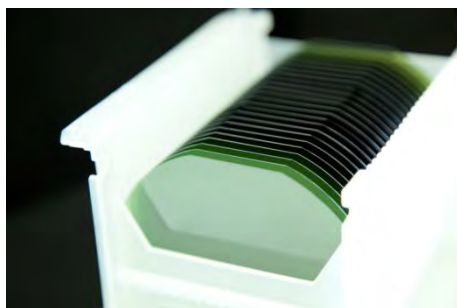
Items	Definition
PDD, DD	Detected and classified by SICA with automatic defect classifying system.
Roughness (Image analysis)	Evaluated by SICA with differential interference optical system, effective for step bunching.
Scratches (Image analysis)	Cumulative length of strings.

Notes:

- Defect limit apply to entire surface except for edge exclusion area.
- Edge exclusion = 3mm for 4" ,6" (2mm for 3")

Options:

- C-surf epi is available.
- Other off orientations are available on request for provided substrates by customer.
- Re-polish on backside after epitaxial growth is available on request.



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Technology road map of SiC epitaxial wafer for power device application

	2015	2016	2017	2018	
The following number are based on 6"model.					
【Uniformity (n epi ≤ 30um) 【 (Target-Max or min) / Target 】					
Carrier concentration (CC)	± 25%	± 20%	± 15%	± 12%	± 10%
Thickness	± 20%	± 12%	± 10%	± 8%	± 6%
【Defect (n epi ≤ 30um)					
SD (count/cm ² : Detected by CS-20)	≤ 1.0	≤ 0.5			Shift to SICA
SICA PDD			≤ 1.2	≤ 0.8	
SICA DD			≤ 2.5	≤ 2.0	
BPD (count/cm ² : caused by process)		≤ 0.2		≤ 0.1	
【CC target limit (n epi)]					
Upper limit of CC target		≤ 2E18	≤ 1E19		
Lower limit of CC target		≥ 5E15	≥ 2E14		
【CC target limit (p epi)]					
Upper limit of CC target		≤ 2E18	≤ 1E19		
Lower limit of CC target		≥ 5E15			
【Development items]					
p epi		CS	Production		
n/p multi layer		CS	Production		
Thick epi	≤ 50	≤ 150	~250		

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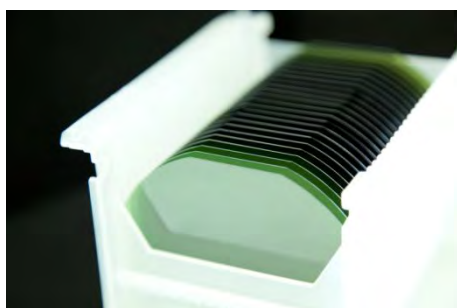
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High Grade Epi BPD performance with SICA evaluation

4inch

n-type Epi (~10um)

	Standard	High Grade
BPD Map		
Density	28.9 cm ⁻²	0.00 cm ⁻²

6inch

n-type Epi (~10um)

	Standard	High Grade
BPD Map		
Density	14.7 cm ⁻²	0.01 cm ⁻²

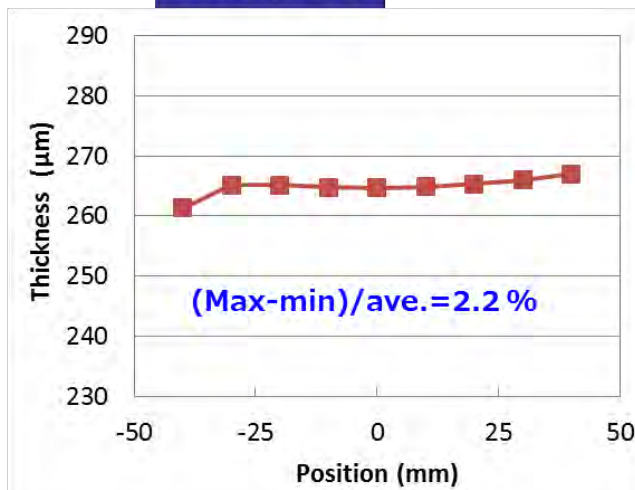
High Grade Epi shows excellent BPD performance in SICA evaluation compared with standard model.



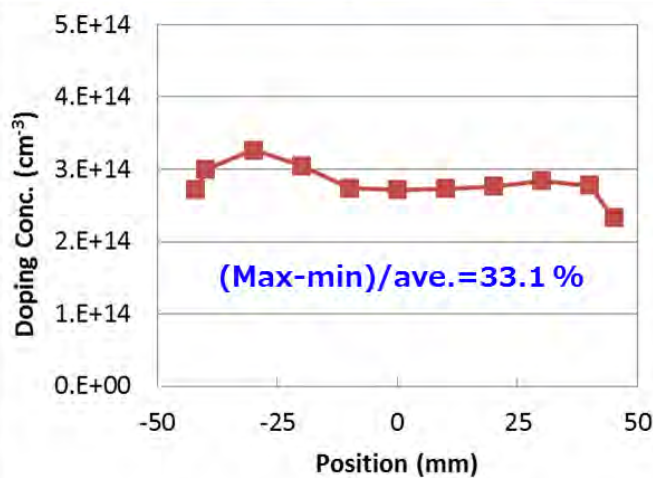
Thick epi performance

High Grade Epi: 4inch n-type (~260um)

Thickness

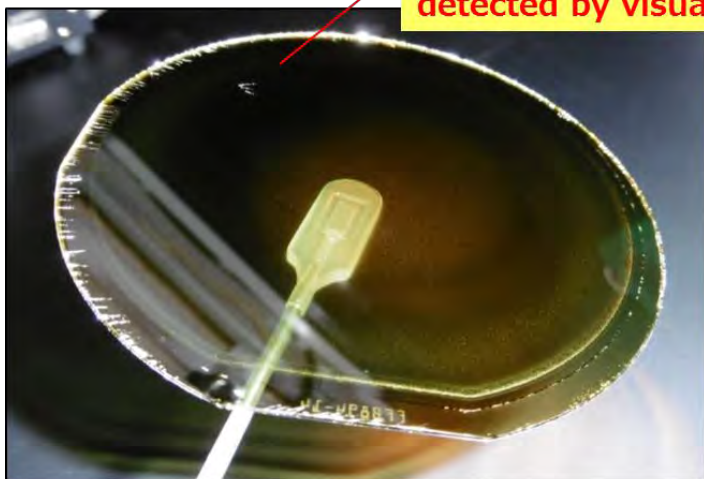


Carrier Concentration

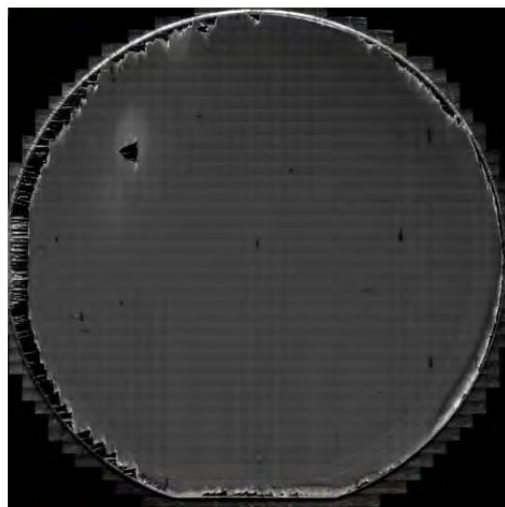


*) FTIR can not evaluate at very od area ($\geq 40\text{mm}$)

Only one triangle defect can be detected by visual.



PL measurement

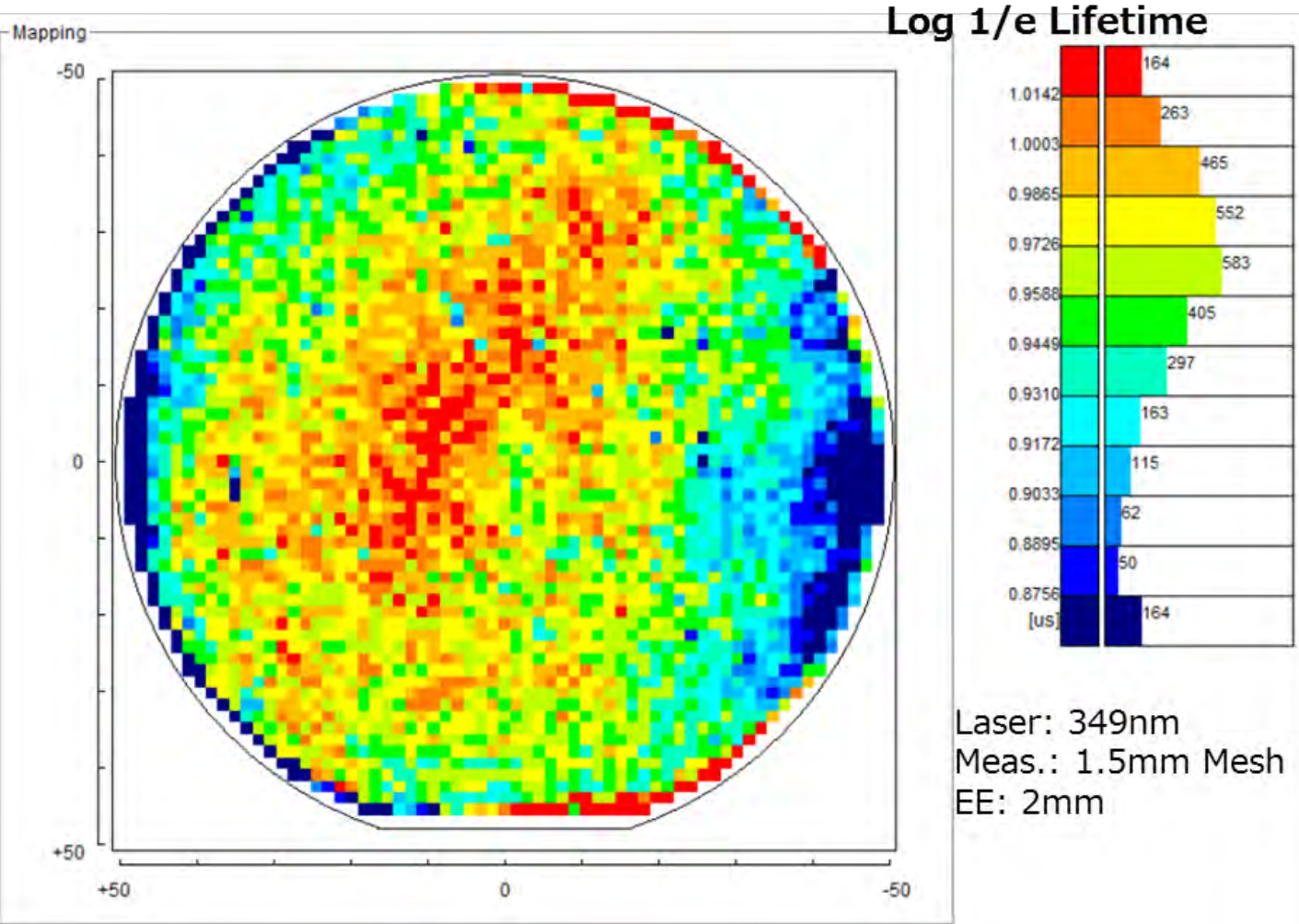


Thick epi layer sample shows good distribution on layer thickness.
CC performance also improved significantly even with 260um of thickness.



Carrier life time (u-PCD)

High Grade: 4inch n-type (100um)



Around 1μsec of carrier life time is observed by u-PCD analysis with 100um epi thickness.